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THE HURRICANE OF OCTOBER 25, 1921, AT TAMPA, FLA.

By EDWARD H. BOWIE, Supervising Forecaster.

[Weather Bureau, Washington, Nov. 28, 1921.]

Like many of the tropical storms of October that pass inland from the east Gulf of Mexico, the one under consideration had its apparent origin over the west-central Caribbean Sea. The first signs of the presence of this disturbance in that region were observed the morning of October 21, although relatively low pressure had been previously reported from bordering stations and from vessels authorized to send meteorological reports by radio. However, on the morning of the 21st when there were signs of the presence of a disturbance in that region, the following advisory information was broadcast:

Advisory 10 a. m. Disturbance appears to be forming over western Caribbean Sea southwest of Jamaica; movement uncertain, but probably northward.

At the time this advice was issued the barometer was high over the United States east of the Mississippi River, low along and off the east coast of the United States, and relatively high southeast of the Bermudas. As to the origin of the storm, little of an authoritative nature may be said, for meteorologists are not yet in agreement as to the forces which bring about their development. It is a matter that is still in the controversial stage. Nevertheless, we do know that they occur along the line of discontinuity which separates the two systems of trade winds—the northeast trades of the Northern, and the southeast trades of the Southern Hemisphere. Perhaps the hypothesis recently stated by Bjerknes to explain the origin of the extra-tropical cyclones will also be found to apply in the case of the tropical cyclones. In connection with the origin of the cyclone under discussion, the following letter from the Chief Hydrographer, Panama Canal, is interesting. It reads as follows:

Reference is made to cabled predictions of the West Indian hurricane of October 21–25. The service on this storm was as satisfactory to shipping here as that of the September 8 to 13, 1921, hurricane.

As usual, we were not detrimentally affected here locally. However, we did have a noticeable effect from it, considerably more than usual. I inclose barometric record, October 12 to 26 (not reproduced). You will note that our barometer, disregarding diurnal fluctuations, was steadily declining from October 13 to 18, preceding the birth of the hurricane. This period was accompanied by heavy daily rains, noticeably on the Pacific half of the Canal Zone; *winds prevailing from northward.*

On the 18th we had an unusual reversion to a more or less steady *southerly* wind of dry season intensity and with dry season characteristics except as for direction; virtually no rain; the above conditions obtaining to October 29.

During October 20–22, inclusive, wind movement averaged 19.4 miles per hour at Balboa Heights against a normal October movement of 6.4. That station had maximum five-minute intensities of 35 miles per hour.

Ships tell us of stormy voyages from San Francisco to Nicaragua contemporaneously with the passage of the Caribbean storm.

We infer from the foregoing that there had taken place previously to the birth of the cyclone fundamental changes in the primary wind régimé of the Tropics. What this had to do in bringing about the birth of the cyclone we do not know, but it is apparent that something more than purely local forces were in operation.

The diagram herewith gives the track of this cyclone from the time it first made its appearance in the Caribbean Sea up to the time it was lost over the Atlantic Ocean south of Bermuda. Up to the time the storm passed inland near Tampa, Fla., the track may be regarded as normal; after that time, decidedly abnormal, the change from normal to abnormal being brought about by the southward-flowing air from an extensive area of high pressure which moved southward from the Hudson Bay during the 25th to 28th. This southward-flowing air-stream controlled the movement of all pilot balloons released at pilot-balloon stations in the Atlantic States north of Florida during this period. This but confirms the opinion of the writer and others that the winds flowing out from and around anticyclones very largely determine the movement of tropical cyclones.

Passing north-northwestward from the position southwest of Jamaica, the cyclone passed near and to the east of Swan Islands on the morning of the 22d. The barometer fell to 29.20 inches, and possibly lower, at that station between 10 a. m. and noon and rose rapidly thereafter. During the afternoon of the same day the wind which had been from the north in the morning shifted to south-southwest and reached a speed of

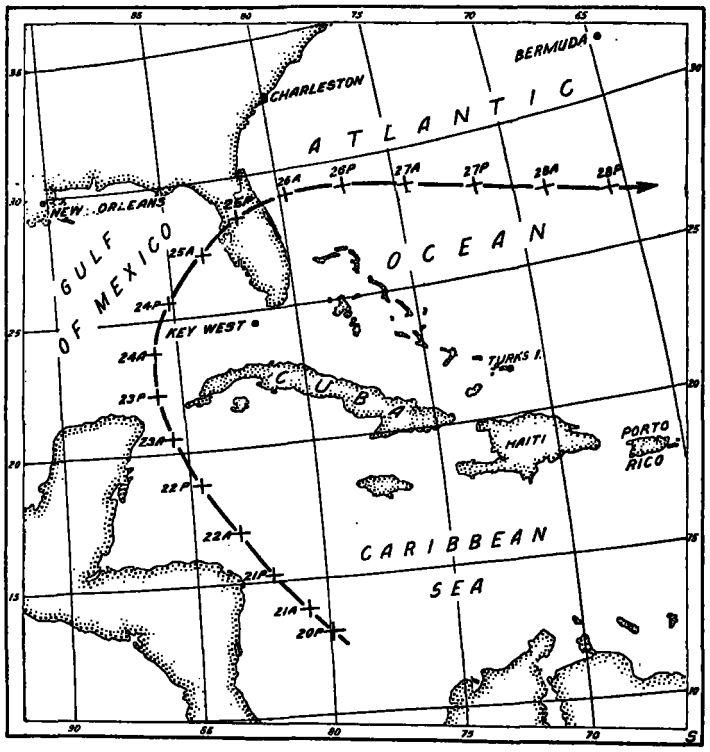

FIG. 1.—Track of tropical hurricane, October 20–28, 1921.

80 miles an hour. Passing Swan Islands the cyclone reached the Yucatan Channel during the 23d, its center passing near Cape San Antonio, Cuba. It seems to have acquired its maximum intensity in this region, as the master of the schooner *Virginia* reported a minimum pressure of 27.80 inches when in the center of the cyclone. The S. S. *El Estero* while in latitude 25° 36′ and longitude 84° 24′, at 10 p. m. of the 24th, encountered the center of the cyclone, the barometer falling to 27.84 inches. The accuracy of the barometer aboard the *Virginia* is not known, but since the reading is not essentially different from the reading made by the observer at Tarpon Springs, near and north of Tampa, when the cyclone was passing inland north of Tampa, it is presumed to be approximately the true low barometer at the center of the disturbance. At Tarpon Springs the barometer as read by Mr. A. P. Albaugh showed a reading of 28.12 inches and at the same time the wind was a dead calm which lasted an hour or more, following 2:15 p. m. of October 25.

During the time that the cyclone was moving northward advisory information and warnings were issued to the threatened land and sea areas, and it is worthy of note that no report of loss of a vessel carrying radio outfit has come to the notice of the Central Office.

Hurricane warnings were ordered noon of the 24th for the west Florida coast from Key West to Apalachicola. The warning read as follows:

Change to hurricane warning at noon, Key West to Apalachicola. Increasing winds and gales and hurricane velocities along the coast. Emergency: warn all interests. Tropical storm near and northwest of west end of Cuba, moving slowly northward and will change its course to north-northeastward during to-day.

After crossing the Florida Peninsula the storm moved almost due east. The last information concerning it received by radio was supplied by the French S. S. *Montana* which came within the influence of the cyclone during the 27th-28th when in longitude 69° 14′ west and latitude 28° 22′ north. The lowest barometer recorded was 29.06 inches.

LOCAL DETAILS.

Local details of the storm, abstracted from reports by meteorologists H. B. Boyer, W. J. Bennett, and A. J. Mitchell, in charge of the Weather Bureau stations at Key West, Tampa, and Jacksonville, respectively, are given below.

METEOROLOGICAL CONDITIONS.

Key West, Fla.—Pressure slowly but steadily decreased from 29.92 inches at 10 a. m. of the 23d to 29.55 inches at 3:30 a. m. of the 24th, while the wind, moderate to fresh from the southeast during the afternoon of the 23d, steadily freshened throughout the 24th, veering from southeast to south between 4 and 5 p. m. and becoming strong. Between 6 and 7 p. m. the force increased to a moderate gale, and between 10 and 11 p. m. to a fresh gale, still blowing from the south. On the 25th the wind veered to southwest at 5 a. m. and 25 minutes later registered its highest velocity of 48 miles an hour. Thence on the force gradually diminished, and during the middle of the afternoon had fallen to fresh and had veered to west.

The rainfall throughout the passing of this storm was light and more or less intermittent, and while the gusty and squally character of the wind invariably accompanying tropical storms was present, this feature was not marked, but during one of these squalls, at 8:06 a. m. of the 25th, the extreme (1-mile) velocity was recorded—54 miles an hour from the southwest.

At the Sand Key station on the Florida reefs, 8 miles south of Key West, the maximum wind velocity recorded was 56 miles an hour from the south at 4 a. m. of the 25th, while the lowest barometric reading was 29.57 inches at the same time.

The heavy seas from the southeast, south, and southwest rolled in over the reef and practically washed away the island that had slowly built up since the hurricane of September, 1919. During the afternoon of the 24th the official in charge at Key West was informed by telephone that the seas were then coming within 5 feet of the recording rain gage. Instructions were given to remove the gage.

Although the employees at Sand Key were assured that violent winds need not be looked for, they were evidently quite nervous in view of the steady encroachment of the heavy seas, and to relieve this tension they were instructed to go to the lighthouse at their discretion. Immediately after the 8 p. m. observation they waded to the lighthouse, where they remained during the night, returning to the Weather Bureau building on the morning of the 25th.

Tampa, Fla.—On Tuesday, the day of the storm, hurricane warnings were ordered continued in the early morning, and distribution made as far as possible. Wires were already going down, but warnings of the previous day had been ample. Telephone and telegraph wires went down about noon, but the storm was near its height, and the office force was busy taking special observations, looking after the instruments, and giving information to anxious visitors who, in spite of the fury of the storm, continually filled the office and brought news of the damage and of the brave work of those who were assisting unfortunates to escape from the rising tide.

It began to rain about 4 a. m. Sunday, October 23, and continued with hardly a break until 9:15 p. m. of the 25th. The total recorded rainfall was 8.53 inches, but much more probably fell and was blown out of the gage. The barometer fell slowly at first, more rapidly after midnight of the 24th–25th, slowed down again between 5 and 7 a. m. and then fell still more rapidly until the minimum, 28.81 inches sea-level pressure, was reached at 2:45 p. m. The lowest previously recorded was 28.95 inches in 1910. After this it rose rapidly to 29.34 inches at 10 p. m. and then more slowly. The wind continued from the northeast during the 24th and the early morning of the 25th, increasing to 28 miles at 3:38 a. m. the early morning of the 25th. It shifted between northeast and east until 7:05 a. m., with velocity between 25 and 42 miles per hour. From 7:05 to 9:50 a. m. the wind was east, with velocity occasionally reaching 40 m. p. h. Southeast winds brought increased velocity, and when the wind changed to south about 2 p. m. it increased to 48 m. p. h. and reached a maximum velocity of 68 m. p. h. at 2:18 p. m. The extreme was 75 m. p. h. The wind had decreased to 30 m. p. h. at 3 p. m., but on the rise of barometer increased again, having shifted to the southwest at 3:10 p. m. The highest velocity with rising barometer was 48 m. p. h. The wind was west only 24 m. p. h. at 8 p. m. Occasional very high gusts occurred during the night, but the maximum did not again reach 30 m. p. h.

Tide on the 24th was 0.7 foot, falling at noon; 0.1 foot, falling at 2 p. m.; zero, falling at 4 p. m. During the night it rose and reached 3.6 feet, and rising at 8 a. m. Further reading could not be obtained, tide being over the tide-gage. The highest tide, however, reached 10.5 feet above mean low water at 2 p. m. as calculated afterwards by the United States Engineers. This is by far the highest ever recorded, the previous record being 5.55 feet.

Jacksonville, Fla.—Pressure distribution on the 21st over the Gulf and the South Atlantic States was such as to make the future course of the storm problematical, the preponderance of positive factors, however, rather favoring a northeast direction over Florida. This conclusion was shaken somewhat on the 22d when conditions seemingly favored a movement to the westward probably around the periphery of the HIGH, then over the East Gulf and South Atlantic States. The circulation at the morning observation of the 22d showed that the Gulf and lower South Atlantic sections were under the direct influence of the storm as it moved slowly northward, cloudiness having enveloped the lower coast line, with a perceptible increase in wind force at lower coast stations as the result of stronger pressure gradients.

The morning reports of the 23d pointed to a continued northward movement. Cloudiness featured all Gulf and lower South Atlantic stations with the rain area embracing practically all of the Florida Peninsula. The morning reports of the 24th showed falling pressure at all Gulf and South Atlantic stations, most pronounced, however, in Florida, with a fresh southeast breeze at Key West and south wind, force 4, at Habana. Night reports of the 24th accentuated the gravity of the situation and abundantly confirmed previous deductions by the Central Office relative to the future movement and intensity of the storm. Fresh breezes prevailed during the day along the northern coast line of Florida with moderate gales to the southward, attended by a 12-hour pressure fall of 0.22 inch at Key West.

The 24-hour rainfall at regular stations, ending at 8 a. m. of the 24th, was:

Station.	Rainfall (inches).
Key West	0.04
Miami	0.44
Titusville	4.26
Tampa	1.00
Jacksonville	0.14
Apalachicola	0.08

Twelve-hour pressure changes (all negative) for the period ending 8 p. m. of the 24th were:

Station.	Pressure fall (hundredths of inch).
Apalachicola	0.14
Jacksonville	0.12
Key West	0.22
Miami	0.12
Tampa and Titusville	0.12

An east-west line at the evening observation of the 24th, bisecting the State about Titusville, showed the wind to be east-southeast and south below, and northeast above, the line of demarcation.

The morning reports of the 25th were far from reassuring; in fact, they awakened a keener interest and a deeper concern by the public. Gales were blowing east of the Suwanee River, attended by torrential rains in much of the central and north-central portion of the peninsula. The night of the 24th–25th was altogether a wild one in the central and northern counties.

Barometer readings at 8 a. m. of the 25th, with 12-hour changes, were as follows:

Weather Bureau stations.	Sea-level pressure (inches).	Pressure fall (inches).
Apalachicola	29.66	0.14
Jacksonville	29.74	0.14
Key West	29.60	0.06
Miami	29.68	0.10
Tampa	29.30	0.44
Titusville	29.64	0.16

The 24-hour rainfall for the period ending at 8 a. m. was as follows:

	Rainfall (inches).
Weather Bureau stations:	
Apalachicola	0.08
Jacksonville	0.34
Key West	0.06
Miami	0.30
Fort Myers	3.30
Tampa	5.20
Titusville	3.02
Weather Bureau cooperative stations:	
Avon Park	5.05
St. Petersburg	5.05
Pinellas Park	7.81
Tarpon Springs	8.70
Brooksville	9.50
Ocala	5.67
Eustis	4.46
Clermont	5.00
McDonald	7.66
Sanford	3.60
Orlando	4.45
Glen St. Mary	4.10
DeLand	3.25
St. Leo	11.73

It will be seen that the greatest rainfall occurred near the path and over the upper-right front and the lower-right rear quadrants as the storm center approached the coast and progressed northeastward across the peninsula.

The usual calm prevailed at the center of the storm, one observer stating that "some blue sky was seen, then it (the wind) broke out from the west, blowing to beat the band."

The lowest barometer readings (mercurial barometers) occurred on the 25th and were as follows:

Station.	Lowest sea-level pressure (inches).	Time of occurrence (hour).
Fort Myers	29.37	Noon.
Jacksonville	29.35	Midnight.
Key West	29.55	5:25 a. m.
Tampa	28.81	2:45 p. m.
Titusville	29.24	8:00 p. m.

The center of the hurricane passed inland just north of Tampa. Fortunately the American S. S. *Truxillo* was able to weather the storm and the master has favored us with the following log for the period midnight of the 24th to midnight of the 25th:

NOVEMBER 22, 1921.

Mr. WALTER J. BENNETT, Meteorologist,
Tampa, Fla.

DEAR SIR: In complying with your request of November 4, am herewith handing you the following. Clock times stated are ninetieth meridian time, or six hours behind Greenwich mean time.

Our position while in the storm center, as near as we can reckon, was approximately 24 sea miles due west of Egmont Key.

Oct. 24. 12 midnight. Bar. 29.62 inches. Therm. 72°. Wind east, blowing hurricane force.

Oct. 25. 4 a. m. Bar. 29.27 inches. Therm. 72°. Wind east, blowing force 11, Beaufort scale.

Oct. 25. 6.30 a. m. Bar. 29.00 inches. Therm. 72°. Wind east, blowing hurricane force.

Oct. 25. 8.00 a. m. Bar. 28.90 inches. Therm. 72°. Wind east, blowing hurricane force.

Oct. 25. 10.20 a. m. Entered storm center. Bar. 28.28 inches. No wind, but a terrific cross sea.

Oct. 25. 10.50 a. m. Passed out storm center. Bar. 28.23 inches. Therm. 72°. Getting wind from west, hurricane force. No wind throughout passage through storm center.
Oct. 25. 11.30 a. m. Bar. 28.32 inches. Wind west, hurricane force.
Oct. 25. Noon. Bar. 28.40 inches. Therm. 72°. Wind west, blowing hurricane force.
Oct. 25. 4 p. m. Bar. 29.02 inches. Therm. 73°. Wind west, blowing force 11.
Oct. 25. 8 p. m. Bar. 29.36 inches. Therm. 72°. Wind north, force 10, weather and sea moderating.
Oct. 25. Midnight. Bar. 29.48 inches. Therm. 71°. Wind north, force 9, weather and sea moderating.

The following barometer readings were taken Tuesday, Nov. 22, 1921, ship lying at Mallory Docks, Tampa, Fla., seventy-fifth meridian time:

8 a. m. Therm. 74°. Bar. 30.17 inches. Tampa station sea-level 30.15.
10 a. m. Therm. 76°. Bar. 30.19 inches. Tampa pressure sea-level, 30.17.
Noon. Therm. 78°. Bar. 30.14 inches. Tampa pressure sea-level, 30.13.
2 p. m. Therm. 78°. Bar. 30.12 inches. Tampa pressure sea-level, 30.09.

Hoping this information will be of benefit to you, I remain,
Very truly, yours,

C. S. HYERS,
Master S. S. "Tamiami."
By S. STANTON,
Chief Officer.

High tides, October 25.—Tampa: The tide was 10.5 feet, the highest since 1848. Egmont and Sanibel Island: Both were practically covered by water. Fort Myers: Tide was 12 to 18 inches higher than previous records for 30 to 35 years. Punta Gorda: Tide was 7 feet above normal high tide at 3 p. m. of 25th; water was in the streets of the city. Punta Rassa: Tide was 6 feet above normal high water. Boca Grande: Tide 5 feet 4 inches above normal high tide at 7.15 a. m. Clearwater: Tide 5 feet above normal high tide, 1.30–4 p. m. St. Petersburg: Tide 8 feet 5 inches above mean low water at 2 p. m.

Maximum wind velocities, with date and direction: Key West, 25th, 48 miles SW. Jacksonville, 25th, 64 miles NE. Mayport, 25th, 54 miles SW. Tampa, 25th, 68 miles S. Tarpon Springs, Dunedin, Egmont Key, and Safety Harbor, all near the center of the storm, estimated the wind velocity as being 80 to 100 miles an hour.

Loss of life.—So far as known the loss of life was small—not exceeding five or six—due, no doubt, to the fact that shipping remained in port.

Loss of shipping.—One coast steamer, the *Vann*, plying between Jacksonville and Miami, foundered off the Jupiter coast about 10 a. m. of the 25th. The value of the vessel and cargo was about $120,000. Several schooners are reported to have capsized off the coast, but definite information is lacking.

Intrastate loss.—The citrus crop sustained a loss 800,000 to 1,000,000 boxes of fruit, approximating a monetary loss of more than $1,000,000. The loss of trees was not great; in fact, the damage from that source was slight. Truck crops adjacent to the coast were greatly damaged—a complete loss in many instances. And the loss of fertilizer and labor greatly augments the disaster, totaling, no doubt, $1,000,000 or more. Salt water flooded many acres, thereby rendering the soil unfit for cultivation in some instances; heavy rain will, however, soon remove the salt deposit, restoring the soil to normal condition.

Miscellaneous damage.—The damage to residences, docks, warehouses, buildings, bridges, and miscellaneous property, at Tampa, Tarpon Springs, St. Petersburg, Sarasota, Punta Gorda, Marco, Caxambus, and Fort Myers; in short, along the coast from a point near Cedar Keys, southward, will exceed $1,000,000, and the aggregate of losses will probably total $3,000,000. The damage on the east coast, while considerable locally, was altogether of little moment when compared with that which befell the west coast.

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THE ELECTRICAL CHARGE OF THE ATMOSPHERE AND THE HEIGHT OF THE BAROMETER.

By W. J. HUMPHREYS.

It has been suggested that many cyclones and anticyclones may be caused by changes in the electrification of the outer atmosphere, such changes, for instance, as presumably occur at the times of brilliant auroræ. It is proposed to check this suggestion by a simple calculation.

Let any considerable, more or less circular, horizontal extent of the upper air be uniformly electrified to the equivalent of a surface charge of density ρ units of electricity per square centimeter, and let the earth immediately beneath have an equal charge of opposite sign.

Now, if there is no other disturbing electrification, the force f on a unit quantity of electricity anywhere between the earth and air charges (assuming, as is approximately true, that the direction of the electric force is everywhere vertical) is given by the well-known equation

$$f = 4\pi\rho$$

of which half is from the air charge and half from the earth charge.

Hence the total electrical pull P between the air and the earth is given by the expression

$$P = 2\pi\rho^2 A \qquad (1)$$

in which A is the area of the charged surface of the earth.

From the value of f, it follows that the work w necessary to carry a unit charge through a difference of level h within the full electric field is

$$w = 4\pi\rho h,$$

or, substituting for ρ its value in terms of P and A, equation (1),

$$w = 4\pi h\sqrt{\frac{P}{2\pi A}}.$$

Hence

$$\left(\frac{w}{h}\right)^2 = 8\pi\frac{P}{A} = 8\pi p \qquad (2)$$

where p = dynes pull on each square centimeter of the electrified surface of the earth, or upper air.

But w/h = ergs work on an electrostatic unit of electricity per its centimeter change in level.

Now, the normal, vertical potential difference in the atmosphere is about one volt per centimeter. Hence, converting to electrostatic units, and substituting in (2),

$$\left(\frac{1}{300}\right)^2 = 8\pi p,$$

or

$$p = 1/2{,}261{,}947.$$

But the weight of one cubic centimeter of mercury at 0° C., and under normal gravity

$$= 13.5951 \times 980.665 \text{ dynes}$$
$$= 13{,}332.24 \text{ dynes}.$$